



# Event generators for two charged and neutral pions production in proton-antiproton annihilation

S. Ong, J. van de Wiele

## ► To cite this version:

S. Ong, J. van de Wiele. Event generators for two charged and neutral pions production in proton-antiproton annihilation. 2008, pp.14. in2p3-00222925

**HAL Id: in2p3-00222925**

**<https://hal.in2p3.fr/in2p3-00222925>**

Submitted on 29 Jan 2008

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Event generators for two charged and neutral pions production in proton-antiproton annihilation

Saro Ong\* and Jacques Van de Wiele

Intitut de Physique Nucléaire, CNRS/IN2P3, Université Paris-Sud, F-91406 Orsay Cedex, France

\* Also Université de Picardie Jules Verne, F-80000 Amiens, France

## 1 Motivations

The backgrounds study of the interesting channel  $p\bar{p} \rightarrow e^+e^-$ , for the proton time-like form factors measurement [1], gives us an opportunity to emphasize the physics case of two-body annihilation  $p\bar{p}$ .

These channels are interesting by themselves and the theoretical predictions need further investigation.

The differential cross section of the charged pions channel is about microbarns/Sr and events have been observed with values of  $S$ , the center of mass energy square, up to 20 GeV<sup>2</sup> [2-4] and 16 GeV<sup>2</sup> for the two neutral pions [5-6]. The data can be divided into the low energy region and the high energy one; the division takes place around  $6 < S < 9$  GeV<sup>2</sup>.

The energy range of FAIR corresponds to the transition domain between the soft mechanisms and the hard scattering ( $S < 30$  GeV<sup>2</sup>). There are many interesting tests namely :

- Dimensional Counting Rule (pQCD) for large  $S$  and fixed large angle [7-9]
- Quark Interchange Dominance in two-body exclusive processes [10]
- Anomalous Regge Behavior (for fixed  $t$  and large  $S \gg -t$ ). The conventional Regge trajectory parameter should become a negative integer at large  $-t$  [11]
- Landshoff hard scattering mechanism [12] for large  $S$  and large cm. scattering angle
- Ralston-Pire oscillations scenario [13] observed in elastic  $pp$  scattering

## 2 Event Generators

In order to respect the previous available data, the event generators can be divided in two different parts. For the low energy part with  $S < 6$  GeV<sup>2</sup>, a Legendre polynomial fit can be performed for charged and neutral channels.

In the high energy range, namely for  $S > 9$  GeV<sup>2</sup>, we assume that the dimensional counting rule holds in respect to the energy dependance of the differential cross section [10]

$$\frac{d\sigma}{dt} = S^{-8} f(\theta) \quad (1)$$

The function  $f(\theta)$  is very sensitive to the scattering mechanism. For the charged channels, The quark Interchange Dominance model predicts the shape of the cross section :

$$\frac{d\sigma}{dt} = C S^{-8} f(\theta) \quad (2)$$

$$f(\theta) = \frac{1}{2}(1 - z^2)[2(1 - z)^{-2} + (1 + z)^{-2}]^2 \quad (3)$$

with  $z = \cos \theta$  and the normalisation constant  $C = 440 \text{ mb GeV}^{14}$  is determined from the  $\pi^+p$  elastic scattering at 10 GeV/c and at  $\cos \theta = 0$ .

Recently, the process  $p\bar{p} \rightarrow \gamma\pi^0$ , within the Handbag approach is investigated by Kroll et al. [14]. The Fermilab (E760) data [6] for  $\pi^0\pi^0$  production in  $p\bar{p}$  annihilation for  $2.91 < \sqrt{S} < 4.27 \text{ GeV}$  exhibit the scaling behavior of the cross section as predicted by the Dimensional counting rule, with a  $S^{-7.18}$  instead of  $S^{-8}$ . For our  $\pi^0\pi^0$  event generator, we assume the following parametrization :

$$\frac{d\sigma}{d\cos\theta} = \frac{f(S, \theta)}{S^6(\sqrt{tu}/S)^4} \quad (4)$$

$$f(S, \theta) = \sum_i a_i(S) P_i(\cos \theta) \quad (5)$$

Where  $P_i(\cos \theta)$  are the Legendre polynomials. Let us noticed that the denominator of the differential cross section reproduced the dependance of  $\sin^4 \theta$  when all masses are neglected in respect to the previous work of Kroll [14].

Numerical results are shown in tables 1 and 2 for the neutral channel with two values of the center of mass energy and in tables 3 and 4 for the charged channel. In the high energy regime (tables 2 and 4), the predictions are valid only for large cm angle scattering; the extrapolation to the forward and backward scatterings is not appropriate.

## References

- [1] Technical Progress Report for Panda, FAIR/ESAC/Pbar, January (2005)
- [2] E. Eisenhandler et al., Nucl. Phys. **B96**, 109 (1975) and References therein
- [3] T. Buran et al., Nucl. Phys. **B116**, 51 (1976)
- [4] A. Berglund et al., Nucl. Phys. **B137**, 276 (1978)
- [5] R.S. Dulude et al., Phys. Lett. **79B**, 329 (1978) and References therein
- [6] T.A. Armstrong et al., Phys. Rev. **D56**, 2509 (1997)
- [7] V.A. Matveev, R.M. Muradian, A.N. Tavkhelidze Lett. Nuovo Cimento **7**, 719 (1973)
- [8] S.J. Brodsky, G.R. Farrar, Phys. Rev.Lett. **31**, 1153 (1973)
- [9] G.P. Lepage, S.J. Brodsky, Phys. Rev. **D22**, 2157 (1980)
- [10] J.F. Gunion, S.J. Brodsky, R. Blankenbecler, Phys. Rev.**D8**, 287 (1973)
- [11] R. Blankenbecler, S.J. Brodsky, J.F. Gunion, R. Savit, Phys. Rev. **D8**, 4117 (1973)
- [12] P. Landshoff, Phys. Rev. **D10**, 1024 (1974)
- [13] J.P. Ralston, B. Pire, Phys. Rev.Lett. **61**, 1823 (1988)
- [14] P. Kroll, A. Schafer, Eur. Phys. J. **A26**, 89 (2005)

Table 1:  $\bar{p} + p \rightarrow \pi^0 + \pi^0$ ;  $\sqrt{S} = 2.1 \text{ GeV}$

$\theta_{cm}$	$\cos(\theta_{cm})$	$d\sigma/d\Omega \text{ (nb/sr)}$
0.00	0.100000E+01	0.271000E+05
0.50	0.999962E+00	0.270980E+05
1.00	0.999848E+00	0.270921E+05
1.50	0.999657E+00	0.270822E+05
2.00	0.999391E+00	0.270683E+05
2.50	0.999048E+00	0.270504E+05
3.00	0.998630E+00	0.270284E+05
3.50	0.998135E+00	0.270024E+05
4.00	0.997564E+00	0.269724E+05
4.50	0.996917E+00	0.269381E+05
5.00	0.996195E+00	0.268998E+05
6.00	0.994522E+00	0.268103E+05
7.00	0.992546E+00	0.267034E+05
8.00	0.990268E+00	0.265787E+05
9.00	0.987688E+00	0.264356E+05
10.00	0.984808E+00	0.262735E+05
12.00	0.978148E+00	0.258896E+05
14.00	0.970296E+00	0.254217E+05
16.00	0.961262E+00	0.248643E+05
18.00	0.951057E+00	0.242126E+05
20.00	0.939693E+00	0.234627E+05
22.00	0.927184E+00	0.226120E+05
24.00	0.913545E+00	0.216601E+05
26.00	0.898794E+00	0.206087E+05
28.00	0.882948E+00	0.194626E+05
30.00	0.866025E+00	0.182294E+05
32.00	0.848048E+00	0.169205E+05
34.00	0.829038E+00	0.155502E+05
36.00	0.809017E+00	0.141366E+05
38.00	0.788011E+00	0.127006E+05
40.00	0.766044E+00	0.112660E+05
42.00	0.743145E+00	0.985869E+04
44.00	0.719340E+00	0.850584E+04
46.00	0.694658E+00	0.723528E+04

48.00	0.669131E+00	0.607432E+04
50.00	0.642788E+00	0.504876E+04
52.00	0.615661E+00	0.418179E+04
54.00	0.587785E+00	0.349294E+04
56.00	0.559193E+00	0.299710E+04
58.00	0.529919E+00	0.270367E+04
60.00	0.500000E+00	0.261591E+04
62.00	0.469472E+00	0.273050E+04
64.00	0.438371E+00	0.303732E+04
66.00	0.406737E+00	0.351961E+04
68.00	0.374607E+00	0.415437E+04
70.00	0.342020E+00	0.491300E+04
72.00	0.309017E+00	0.576231E+04
74.00	0.275637E+00	0.666572E+04
76.00	0.241922E+00	0.758461E+04
78.00	0.207912E+00	0.847985E+04
80.00	0.173648E+00	0.931341E+04
82.00	0.139173E+00	0.100499E+05
84.00	0.104528E+00	0.106579E+05
86.00	0.697565E-01	0.111117E+05
88.00	0.348995E-01	0.113920E+05
90.00	0.612303E-16	0.114867E+05
92.00	-0.348995E-01	0.113920E+05
94.00	-0.697565E-01	0.111117E+05
96.00	-0.104528E+00	0.106579E+05
98.00	-0.139173E+00	0.100499E+05
100.00	-0.173648E+00	0.931341E+04
102.00	-0.207912E+00	0.847985E+04
104.00	-0.241922E+00	0.758461E+04
106.00	-0.275637E+00	0.666572E+04
108.00	-0.309017E+00	0.576231E+04
110.00	-0.342020E+00	0.491300E+04
112.00	-0.374607E+00	0.415437E+04
114.00	-0.406737E+00	0.351961E+04
116.00	-0.438371E+00	0.303732E+04
118.00	-0.469472E+00	0.273050E+04
120.00	-0.500000E+00	0.261591E+04

122.00	-0.529919E+00	0.270367E+04
124.00	-0.559193E+00	0.299710E+04
126.00	-0.587785E+00	0.349294E+04
128.00	-0.615661E+00	0.418179E+04
130.00	-0.642788E+00	0.504876E+04
132.00	-0.669131E+00	0.607432E+04
134.00	-0.694658E+00	0.723528E+04
136.00	-0.719340E+00	0.850584E+04
138.00	-0.743145E+00	0.985869E+04
140.00	-0.766044E+00	0.112660E+05
142.00	-0.788011E+00	0.127006E+05
144.00	-0.809017E+00	0.141366E+05
146.00	-0.829038E+00	0.155502E+05
148.00	-0.848048E+00	0.169205E+05
150.00	-0.866025E+00	0.182294E+05
152.00	-0.882948E+00	0.194626E+05
154.00	-0.898794E+00	0.206087E+05
156.00	-0.913545E+00	0.216601E+05
158.00	-0.927184E+00	0.226120E+05
160.00	-0.939693E+00	0.234627E+05
162.00	-0.951057E+00	0.242126E+05
164.00	-0.961262E+00	0.248643E+05
166.00	-0.970296E+00	0.254217E+05
168.00	-0.978148E+00	0.258896E+05
170.00	-0.984808E+00	0.262735E+05
171.00	-0.987688E+00	0.264356E+05
172.00	-0.990268E+00	0.265787E+05
173.00	-0.992546E+00	0.267034E+05
174.00	-0.994522E+00	0.268103E+05
175.00	-0.996195E+00	0.268998E+05
176.00	-0.997564E+00	0.269724E+05
177.00	-0.998630E+00	0.270284E+05
178.00	-0.999391E+00	0.270683E+05
180.00	-0.100000E+01	0.271000E+05

Table 2:  $\bar{p} + p \rightarrow \pi^0 + \pi^0$ ;  $\sqrt{S} = 2.911 \text{ GeV}$

$\theta_{cm}$	$\cos(\theta_{cm})$	$d\sigma/d\cos(\theta_{cm}) \text{ (nb)}$
35.00	0.8192E+00	0.5223E+06
36.00	0.8090E+00	0.4118E+06
37.00	0.7986E+00	0.3225E+06
38.00	0.7880E+00	0.2507E+06
39.00	0.7771E+00	0.1932E+06
40.00	0.7660E+00	0.1474E+06
41.00	0.7547E+00	0.1112E+06
42.00	0.7431E+00	0.8288E+05
43.00	0.7314E+00	0.6084E+05
44.00	0.7193E+00	0.4389E+05
45.00	0.7071E+00	0.3102E+05
46.00	0.6947E+00	0.2140E+05
47.00	0.6820E+00	0.1433E+05
48.00	0.6691E+00	0.9263E+04
49.00	0.6561E+00	0.5733E+04
50.00	0.6428E+00	0.3375E+04
51.00	0.6293E+00	0.1890E+04
52.00	0.6157E+00	0.1044E+04
53.00	0.6018E+00	0.6486E+03
54.00	0.5878E+00	0.5590E+03
55.00	0.5736E+00	0.6630E+03
56.00	0.5592E+00	0.8761E+03
57.00	0.5446E+00	0.1136E+04
58.00	0.5299E+00	0.1399E+04
59.00	0.5150E+00	0.1635E+04
60.00	0.5000E+00	0.1825E+04
61.00	0.4848E+00	0.1960E+04
62.00	0.4695E+00	0.2035E+04
63.00	0.4540E+00	0.2052E+04
64.00	0.4384E+00	0.2017E+04
65.00	0.4226E+00	0.1935E+04
66.00	0.4067E+00	0.1817E+04
67.00	0.3907E+00	0.1669E+04
68.00	0.3746E+00	0.1503E+04

69.00	0.3584E+00	0.1325E+04
70.00	0.3420E+00	0.1144E+04
71.00	0.3256E+00	0.9674E+03
72.00	0.3090E+00	0.7997E+03
73.00	0.2924E+00	0.6460E+03
74.00	0.2756E+00	0.5096E+03
75.00	0.2588E+00	0.3928E+03
76.00	0.2419E+00	0.2965E+03
77.00	0.2250E+00	0.2211E+03
78.00	0.2079E+00	0.1657E+03
79.00	0.1908E+00	0.1289E+03
80.00	0.1736E+00	0.1086E+03
81.00	0.1564E+00	0.1024E+03
82.00	0.1392E+00	0.1075E+03
83.00	0.1219E+00	0.1209E+03
84.00	0.1045E+00	0.1398E+03
85.00	0.8716E-01	0.1613E+03
86.00	0.6976E-01	0.1828E+03
87.00	0.5234E-01	0.2020E+03
88.00	0.3490E-01	0.2171E+03
89.00	0.1745E-01	0.2267E+03
90.00	0.6123E-16	0.2301E+03
91.00	-0.1745E-01	0.2267E+03
92.00	-0.3490E-01	0.2171E+03
93.00	-0.5234E-01	0.2020E+03
94.00	-0.6976E-01	0.1828E+03
95.00	-0.8716E-01	0.1613E+03
96.00	-0.1045E+00	0.1398E+03
97.00	-0.1219E+00	0.1209E+03
98.00	-0.1392E+00	0.1075E+03
99.00	-0.1564E+00	0.1024E+03
100.00	-0.1736E+00	0.1086E+03
101.00	-0.1908E+00	0.1289E+03
102.00	-0.2079E+00	0.1657E+03
103.00	-0.2250E+00	0.2211E+03
104.00	-0.2419E+00	0.2965E+03
105.00	-0.2588E+00	0.3928E+03



106.00	-0.2756E+00	0.5096E+03
107.00	-0.2924E+00	0.6460E+03
108.00	-0.3090E+00	0.7997E+03
109.00	-0.3256E+00	0.9674E+03
110.00	-0.3420E+00	0.1144E+04
111.00	-0.3584E+00	0.1325E+04
112.00	-0.3746E+00	0.1503E+04
113.00	-0.3907E+00	0.1669E+04
114.00	-0.4067E+00	0.1817E+04
115.00	-0.4226E+00	0.1935E+04
116.00	-0.4384E+00	0.2017E+04
117.00	-0.4540E+00	0.2052E+04
118.00	-0.4695E+00	0.2035E+04
119.00	-0.4848E+00	0.1960E+04
120.00	-0.5000E+00	0.1825E+04
121.00	-0.5150E+00	0.1635E+04
122.00	-0.5299E+00	0.1399E+04
123.00	-0.5446E+00	0.1136E+04
124.00	-0.5592E+00	0.8761E+03
125.00	-0.5736E+00	0.6630E+03
126.00	-0.5878E+00	0.5590E+03
127.00	-0.6018E+00	0.6486E+03
128.00	-0.6157E+00	0.1044E+04
129.00	-0.6293E+00	0.1890E+04
130.00	-0.6428E+00	0.3375E+04
131.00	-0.6561E+00	0.5733E+04
132.00	-0.6691E+00	0.9263E+04
133.00	-0.6820E+00	0.1433E+05
134.00	-0.6947E+00	0.2140E+05
135.00	-0.7071E+00	0.3102E+05
136.00	-0.7193E+00	0.4389E+05
137.00	-0.7314E+00	0.6084E+05
138.00	-0.7431E+00	0.8288E+05
139.00	-0.7547E+00	0.1112E+06
140.00	-0.7660E+00	0.1474E+06
141.00	-0.7771E+00	0.1932E+06
142.00	-0.7880E+00	0.2507E+06
143.00	-0.7986E+00	0.3225E+06
144.00	-0.8090E+00	0.4118E+06
145.00	-0.8192E+00	0.5223E+06

Table 3:  $\bar{p} + p \rightarrow \pi^+ + \pi^-$ ;  $\sqrt{S} = 2.016 \text{ GeV}$

$\theta_{cm}$	$\cos(\theta_{cm})$	$d\sigma/d\Omega \text{ (nb/sr)}$
0.00	0.100000E+01	0.133340E+06
0.50	0.999962E+00	0.133312E+06
1.00	0.999848E+00	0.133230E+06
1.50	0.999657E+00	0.133093E+06
2.00	0.999391E+00	0.132902E+06
2.50	0.999048E+00	0.132657E+06
3.00	0.998630E+00	0.132357E+06
3.50	0.998135E+00	0.132005E+06
4.00	0.997564E+00	0.131599E+06
4.50	0.996917E+00	0.131141E+06
5.00	0.996195E+00	0.130631E+06
6.00	0.994522E+00	0.129458E+06
7.00	0.992546E+00	0.128087E+06
8.00	0.990268E+00	0.126525E+06
9.00	0.987688E+00	0.124779E+06
10.00	0.984808E+00	0.122860E+06
12.00	0.978148E+00	0.118537E+06
14.00	0.970296E+00	0.113641E+06
16.00	0.961262E+00	0.108262E+06
18.00	0.951057E+00	0.102496E+06
20.00	0.939693E+00	0.964399E+05
22.00	0.927184E+00	0.901876E+05
24.00	0.913545E+00	0.838304E+05
26.00	0.898794E+00	0.774537E+05
28.00	0.882948E+00	0.711359E+05
30.00	0.866025E+00	0.649481E+05
32.00	0.848048E+00	0.589536E+05
34.00	0.829038E+00	0.532083E+05
36.00	0.809017E+00	0.477609E+05
38.00	0.788011E+00	0.426534E+05
40.00	0.766044E+00	0.379218E+05
42.00	0.743145E+00	0.335960E+05
44.00	0.719340E+00	0.297000E+05
46.00	0.694658E+00	0.262517E+05

48.00	0.669131E+00	0.232622E+05
50.00	0.642788E+00	0.207353E+05
52.00	0.615661E+00	0.186664E+05
54.00	0.587785E+00	0.170422E+05
56.00	0.559193E+00	0.158400E+05
58.00	0.529919E+00	0.150278E+05
60.00	0.500000E+00	0.145652E+05
62.00	0.469472E+00	0.144041E+05
64.00	0.438371E+00	0.144912E+05
66.00	0.406737E+00	0.147701E+05
68.00	0.374607E+00	0.151844E+05
70.00	0.342020E+00	0.156808E+05
72.00	0.309017E+00	0.162119E+05
74.00	0.275637E+00	0.167393E+05
76.00	0.241922E+00	0.172348E+05
78.00	0.207912E+00	0.176817E+05
80.00	0.173648E+00	0.180747E+05
82.00	0.139173E+00	0.184181E+05
84.00	0.104528E+00	0.187231E+05
86.00	0.697565E-01	0.190049E+05
88.00	0.348995E-01	0.192781E+05
90.00	0.612303E-16	0.195530E+05
92.00	-0.348995E-01	0.198316E+05
94.00	-0.697565E-01	0.201053E+05
96.00	-0.104528E+00	0.203534E+05
98.00	-0.139173E+00	0.205438E+05
100.00	-0.173648E+00	0.206359E+05
102.00	-0.207912E+00	0.205849E+05
104.00	-0.241922E+00	0.203487E+05
106.00	-0.275637E+00	0.198956E+05
108.00	-0.309017E+00	0.192124E+05
110.00	-0.342020E+00	0.183126E+05
112.00	-0.374607E+00	0.172433E+05
114.00	-0.406737E+00	0.160898E+05
116.00	-0.438371E+00	0.149768E+05
118.00	-0.469472E+00	0.140667E+05
120.00	-0.500000E+00	0.135532E+05

122.00	-0.529919E+00	0.136511E+05
124.00	-0.559193E+00	0.145821E+05
126.00	-0.587785E+00	0.165589E+05
128.00	-0.615661E+00	0.197661E+05
130.00	-0.642788E+00	0.243419E+05
132.00	-0.669131E+00	0.303613E+05
134.00	-0.694658E+00	0.378215E+05
136.00	-0.719340E+00	0.466329E+05
138.00	-0.743145E+00	0.566152E+05
140.00	-0.766044E+00	0.675003E+05
142.00	-0.788011E+00	0.789431E+05
144.00	-0.809017E+00	0.905373E+05
146.00	-0.829038E+00	0.101839E+06
148.00	-0.848048E+00	0.112395E+06
150.00	-0.866025E+00	0.121769E+06
152.00	-0.882948E+00	0.129576E+06
154.00	-0.898794E+00	0.135510E+06
156.00	-0.913545E+00	0.139365E+06
158.00	-0.927184E+00	0.141058E+06
160.00	-0.939693E+00	0.140632E+06
162.00	-0.951057E+00	0.138262E+06
164.00	-0.961262E+00	0.134242E+06
166.00	-0.970296E+00	0.128970E+06
168.00	-0.978148E+00	0.122919E+06
170.00	-0.984808E+00	0.116605E+06
171.00	-0.987688E+00	0.113514E+06
172.00	-0.990268E+00	0.110551E+06
173.00	-0.992546E+00	0.107778E+06
174.00	-0.994522E+00	0.105251E+06
175.00	-0.996195E+00	0.103020E+06
176.00	-0.997564E+00	0.101130E+06
177.00	-0.998630E+00	0.996197E+05
178.00	-0.999391E+00	0.985187E+05
180.00	-0.100000E+01	0.976246E+05

Table 4:  $\bar{p} + p \rightarrow \pi^+ + \pi^-$ ;  $T_{cin} = 5 \text{ GeV}$

$\theta_{cm}$	$\cos(\theta_{cm})$	$d\sigma/d\Omega \text{ (nb/sr)}$
35.00	0.8192E+00	0.3104E+03
36.00	0.8090E+00	0.2624E+03
37.00	0.7986E+00	0.2229E+03
38.00	0.7880E+00	0.1902E+03
39.00	0.7771E+00	0.1630E+03
40.00	0.7660E+00	0.1402E+03
41.00	0.7547E+00	0.1211E+03
42.00	0.7431E+00	0.1050E+03
43.00	0.7314E+00	0.9139E+02
44.00	0.7193E+00	0.7980E+02
45.00	0.7071E+00	0.6990E+02
46.00	0.6947E+00	0.6143E+02
47.00	0.6820E+00	0.5415E+02
48.00	0.6691E+00	0.4787E+02
49.00	0.6561E+00	0.4245E+02
50.00	0.6428E+00	0.3774E+02
51.00	0.6293E+00	0.3364E+02
52.00	0.6157E+00	0.3007E+02
53.00	0.6018E+00	0.2694E+02
54.00	0.5878E+00	0.2420E+02
55.00	0.5736E+00	0.2180E+02
56.00	0.5592E+00	0.1967E+02
57.00	0.5446E+00	0.1780E+02
58.00	0.5299E+00	0.1614E+02
59.00	0.5150E+00	0.1467E+02
60.00	0.5000E+00	0.1336E+02
61.00	0.4848E+00	0.1220E+02
62.00	0.4695E+00	0.1116E+02
63.00	0.4540E+00	0.1023E+02
64.00	0.4384E+00	0.9397E+01
65.00	0.4226E+00	0.8652E+01
66.00	0.4067E+00	0.7983E+01
67.00	0.3907E+00	0.7380E+01
68.00	0.3746E+00	0.6838E+01

69.00	0.3584E+00	0.6349E+01
70.00	0.3420E+00	0.5907E+01
71.00	0.3256E+00	0.5508E+01
72.00	0.3090E+00	0.5146E+01
73.00	0.2924E+00	0.4819E+01
74.00	0.2756E+00	0.4522E+01
75.00	0.2588E+00	0.4253E+01
76.00	0.2419E+00	0.4009E+01
77.00	0.2250E+00	0.3787E+01
78.00	0.2079E+00	0.3585E+01
79.00	0.1908E+00	0.3402E+01
80.00	0.1736E+00	0.3236E+01
81.00	0.1564E+00	0.3086E+01
82.00	0.1392E+00	0.2949E+01
83.00	0.1219E+00	0.2825E+01
84.00	0.1045E+00	0.2713E+01
85.00	0.8716E-01	0.2613E+01
86.00	0.6976E-01	0.2522E+01
87.00	0.5234E-01	0.2441E+01
88.00	0.3490E-01	0.2368E+01
89.00	0.1745E-01	0.2304E+01
90.00	0.6123E-16	0.2248E+01
91.00	-0.1745E-01	0.2200E+01
92.00	-0.3490E-01	0.2158E+01
93.00	-0.5234E-01	0.2123E+01
94.00	-0.6976E-01	0.2095E+01
95.00	-0.8716E-01	0.2074E+01
96.00	-0.1045E+00	0.2059E+01
97.00	-0.1219E+00	0.2050E+01
98.00	-0.1392E+00	0.2047E+01
99.00	-0.1564E+00	0.2051E+01
100.00	-0.1736E+00	0.2061E+01
101.00	-0.1908E+00	0.2077E+01
102.00	-0.2079E+00	0.2101E+01
103.00	-0.2250E+00	0.2131E+01
104.00	-0.2419E+00	0.2169E+01
105.00	-0.2588E+00	0.2215E+01

106.00	-0.2756E+00	0.2269E+01
107.00	-0.2924E+00	0.2331E+01
108.00	-0.3090E+00	0.2404E+01
109.00	-0.3256E+00	0.2487E+01
110.00	-0.3420E+00	0.2581E+01
111.00	-0.3584E+00	0.2687E+01
112.00	-0.3746E+00	0.2807E+01
113.00	-0.3907E+00	0.2942E+01
114.00	-0.4067E+00	0.3093E+01
115.00	-0.4226E+00	0.3263E+01
116.00	-0.4384E+00	0.3454E+01
117.00	-0.4540E+00	0.3668E+01
118.00	-0.4695E+00	0.3907E+01
119.00	-0.4848E+00	0.4176E+01
120.00	-0.5000E+00	0.4478E+01
121.00	-0.5150E+00	0.4818E+01
122.00	-0.5299E+00	0.5200E+01
123.00	-0.5446E+00	0.5631E+01
124.00	-0.5592E+00	0.6118E+01
125.00	-0.5736E+00	0.6668E+01
126.00	-0.5878E+00	0.7292E+01
127.00	-0.6018E+00	0.8002E+01
128.00	-0.6157E+00	0.8809E+01
129.00	-0.6293E+00	0.9732E+01
130.00	-0.6428E+00	0.1079E+02
131.00	-0.6561E+00	0.1200E+02
132.00	-0.6691E+00	0.1339E+02
133.00	-0.6820E+00	0.1500E+02
134.00	-0.6947E+00	0.1686E+02
135.00	-0.7071E+00	0.1903E+02
136.00	-0.7193E+00	0.2155E+02
137.00	-0.7314E+00	0.2451E+02
138.00	-0.7431E+00	0.2798E+02
139.00	-0.7547E+00	0.3207E+02
140.00	-0.7660E+00	0.3691E+02
141.00	-0.7771E+00	0.4267E+02
142.00	-0.7880E+00	0.4956E+02
143.00	-0.7986E+00	0.5782E+02
144.00	-0.8090E+00	0.6780E+02
145.00	-0.8192E+00	0.7990E+02